

# Hyper Transport Testing

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**Platform**  
Conference  
Direction • Design • Perspective • Analysis



# What Is HyperTransport

- **Co-developed by AMD and API Networks**
  - *Teradyne started working with co-developers on Rev0.0 of HyperTransport specification more than 2 years ago!*
  - Both developers have selected Teradyne for this exciting new technology
- **Unidirectional point-to-point links**
- **Uses high speed, low voltage differential signaling (LVDS)**
  - LVDS – Industry standard protocol for low voltage differential signaling
  - HyperTransport is a super set of LVDS
- **Uses variable link widths and speeds based on necessary BW**
  - Communications applications: < 8 bits
  - PC applications: 8 to 32 bits



# Key HyperTransport Tests

- Three main test categories

- Levels

- Timing

- Impedance

	Levels Test				Differential Impedance Tests		Timing Tests
	DC		AC				
	Common mode Levels	Differential Levels	Common mode Levels	Differential Levels	Impedance Measure	Impedance Verify	Timing Skew
<b>Tx</b>	<b>Vocm</b>	<b>Vod</b>	<b>Vocm</b>	<b>Vod</b>	<b>Ron</b>	<b>Ron</b>	<b>Tclk, Tcad</b>
<b>Rx</b>	<b>Vicm</b>	<b>Vid</b>	<b>Vicm</b>	<b>Vid</b>	<b>Rt</b>	<b>Rt</b>	<b>Tsetup, Thold</b>

**Test Requirement: Complete test coverage in a single pass test**



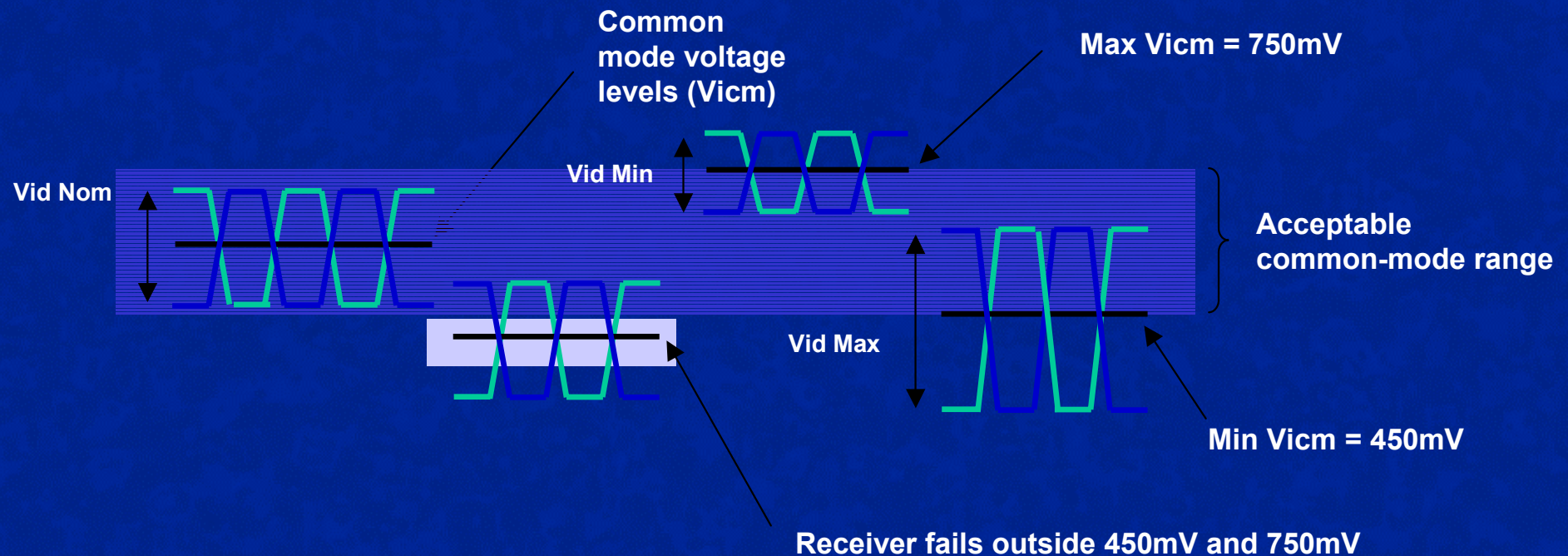
# Common-mode Levels Tests

	Levels Test				Differential Impedance Tests		Timing Tests
	DC		AC				
	Common mode Levels	Differential Levels	Common mode Levels	Differential Levels	Impedance Measure	Impedance Verify	Timing Skew
Tx	Vocm	Vod	Vocm	Vod	Ron	Ron	Tclk, Tcad
Rx	Vicm	Vid	Vicm	Vid	Rt	Rt	Tsetup, Thold



# Common-mode Shift

- Common Mode Output Vocm
  - 500mV to 700mV with nominal @ 600mV
  - Specification is based on receiver's ability to comply with common-mode shift
- Common Mode Input Vicm
  - 450mV to 750mV with nominal @ 600mV
  - Common-mode shift is injected primarily from transmission path and less so from transmitter
- Causes for common-mode shift:
  - Differences in ground planes voltage distribution
  - Driver offset voltage
  - Coupled noise from transmission

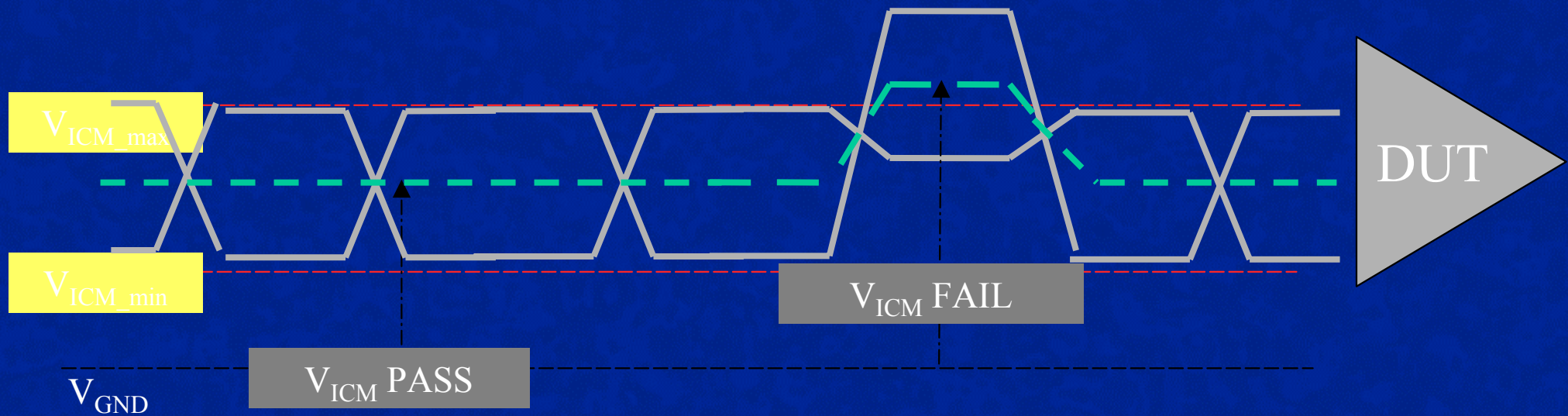




# Testing Input Common Mode

## ■ Receiver Common Mode Rejection Test (AC)

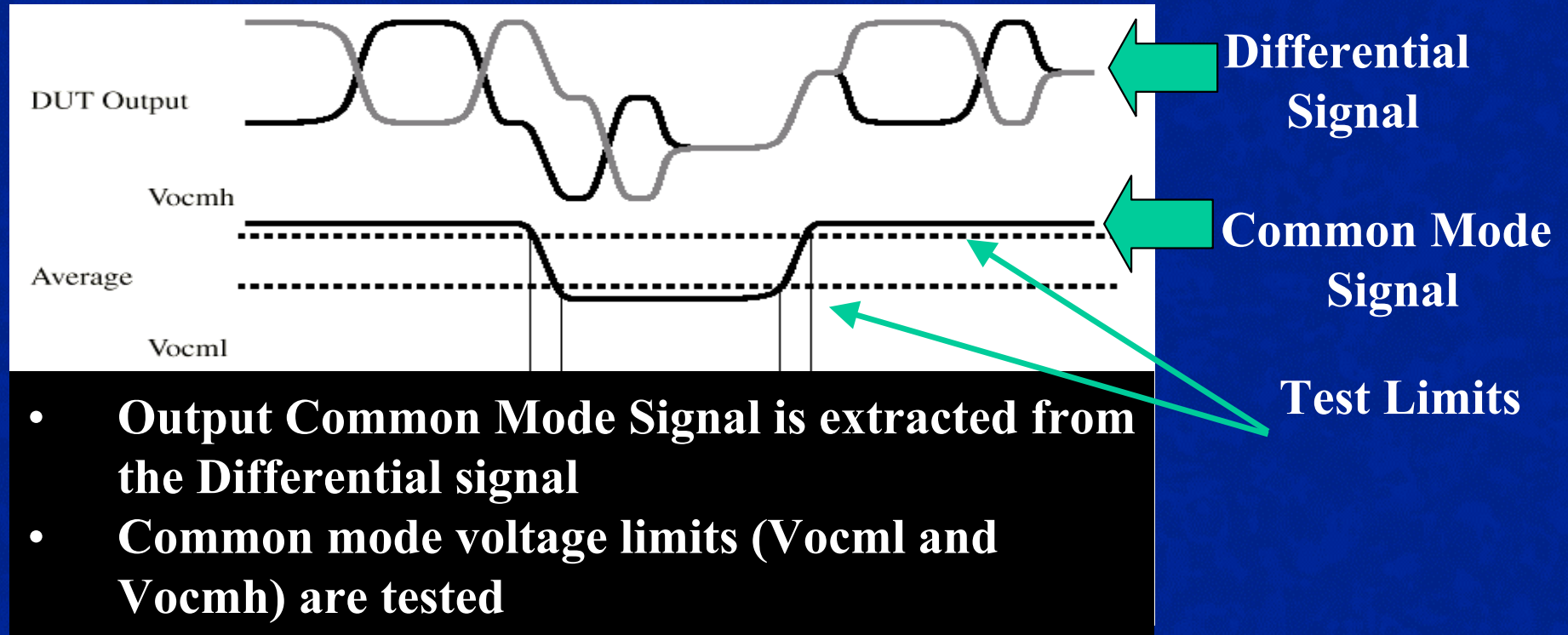
- Exercise at-speed functional test pattern
- Vector by Vector change common mode level on the fly
- Observe functional Pass/Fail



**Test Requirement: Provide a differential signal to the HyperTransport receiver that has a varying common mode during the pattern burst**



# Testing Output Common-mode



**Test Requirement:** Capture the common mode of the differential output and make a pass/fail decision based on programmed limits



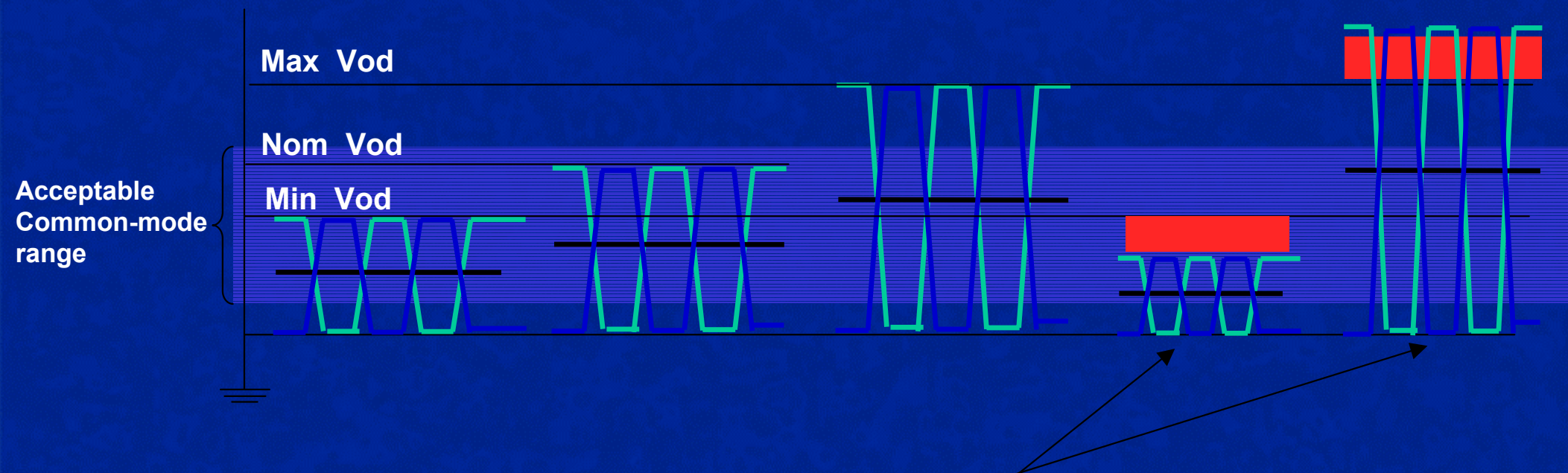
# Differential Levels Tests

	Levels Test				Differential Impedance Tests		Timing Tests
	DC		AC				
	Common mode Levels	Differential Levels	Common mode Levels	Differential Levels	Impedance Measure	Impedance Verify	Timing Skew
Tx	Vocm	Vod	Vocm	Vod	Ron	Ron	Tclk, Tcad
Rx	Vicm	Vid	Vicm	Vid	Rt	Rt	Tsetup, Thold



# Differential Levels Test

- Differential output levels  $V_{od}$ 
  - 400mV to 700mV with nominal @ 600mV
- Differential input levels  $V_{id}$ 
  - 200mV to 1000mV with nominal @ 600mV
- Causes for differential levels shift:
  - Differences in ground planes voltage distribution
  - Driver offset voltage
  - Coupled noise from transmission



**Fails differential levels test but within acceptable common-range mode**



# Testing Output Differential Levels

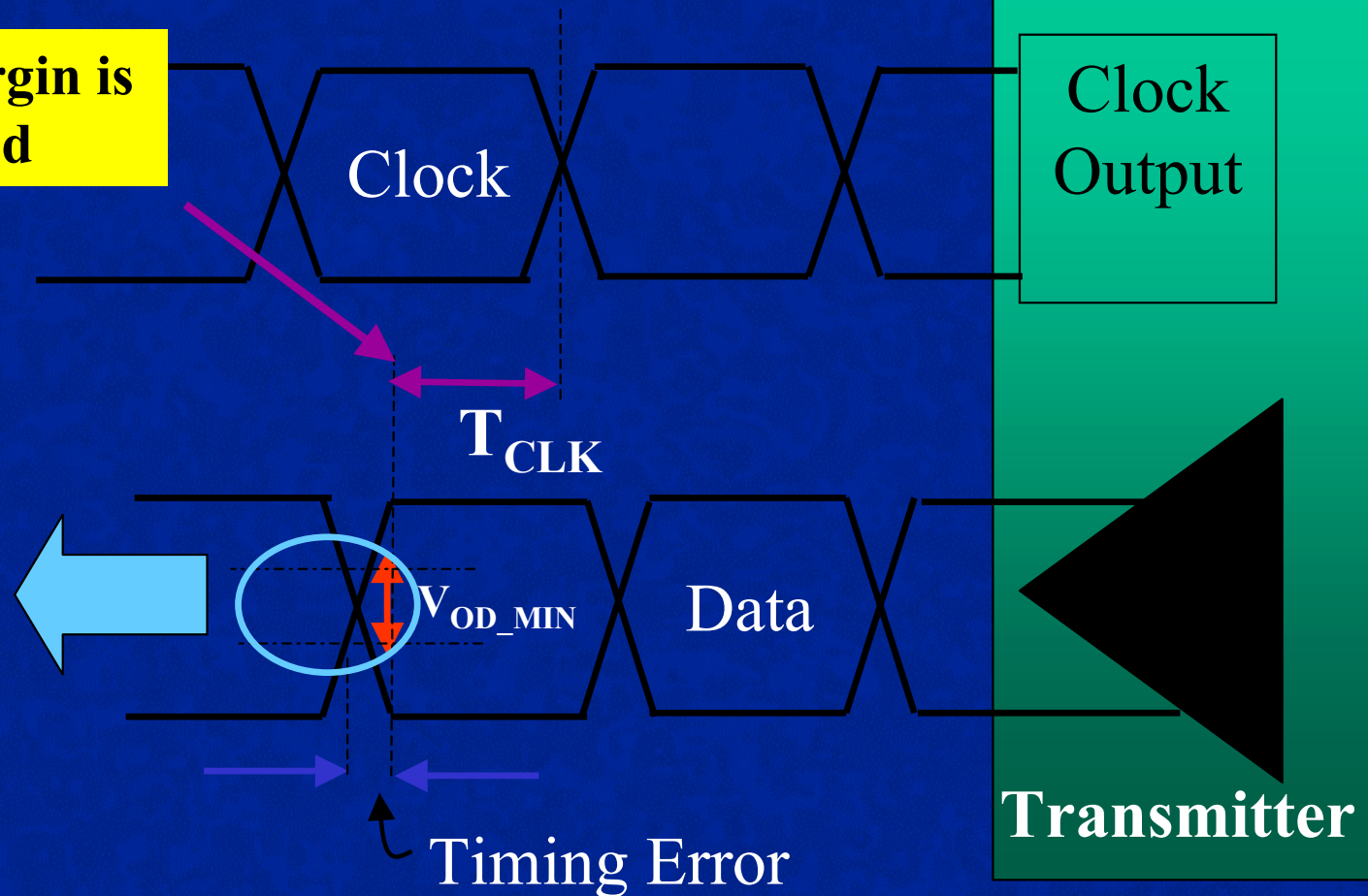
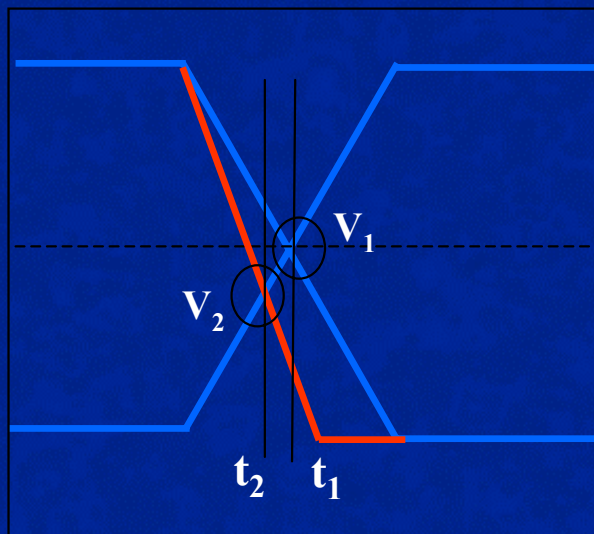
## Voltage Inaccuracies = Timing Inaccuracies

### Differential Transmit:

- Differential signal cross-points impact timing specs
- Voltage inaccuracies in detecting the cross-point translate to timing inaccuracies.
- Low voltage signals aggravate the measurement inaccuracy

**Timing Margin is Reduced**

$$\% \text{ Error} = \frac{V_1 - V_2}{\text{Total Swing}}$$





# Testing Output Differential Levels

**DUT Output Differential Signal**

DUT Output

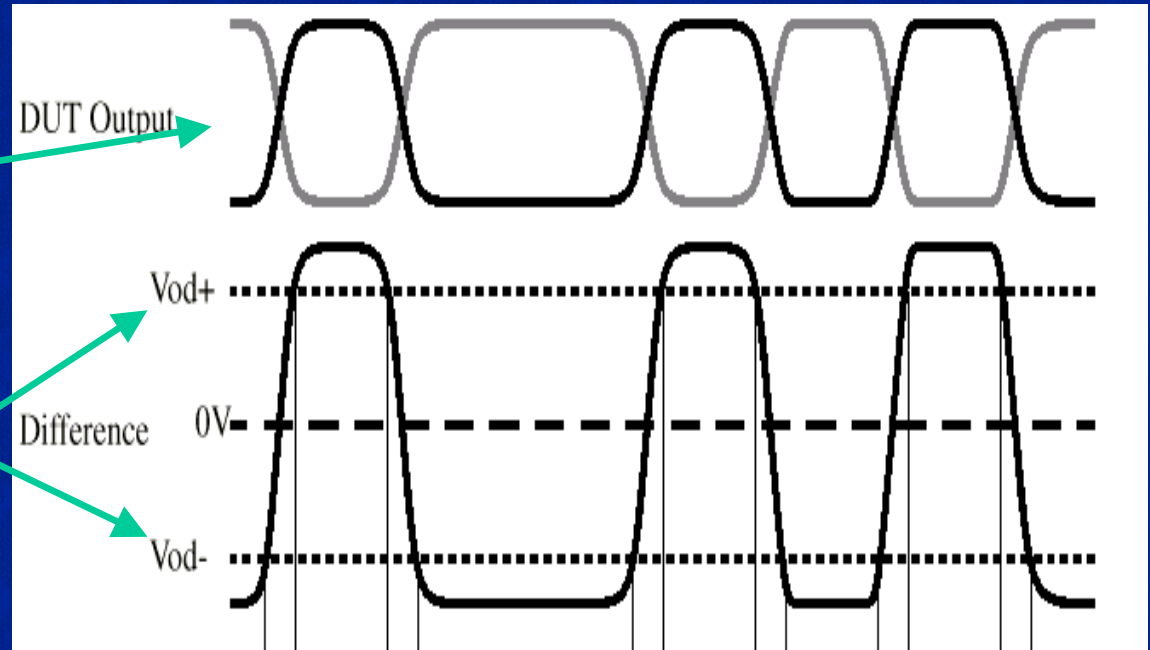
**Differential Output Test Limits**

Difference

Vod+

0V

Vod-



**Test Requirement:**

- Detect differential signal and measure the difference of the true and complement signal.
- Impose test limits on the output differential signal.

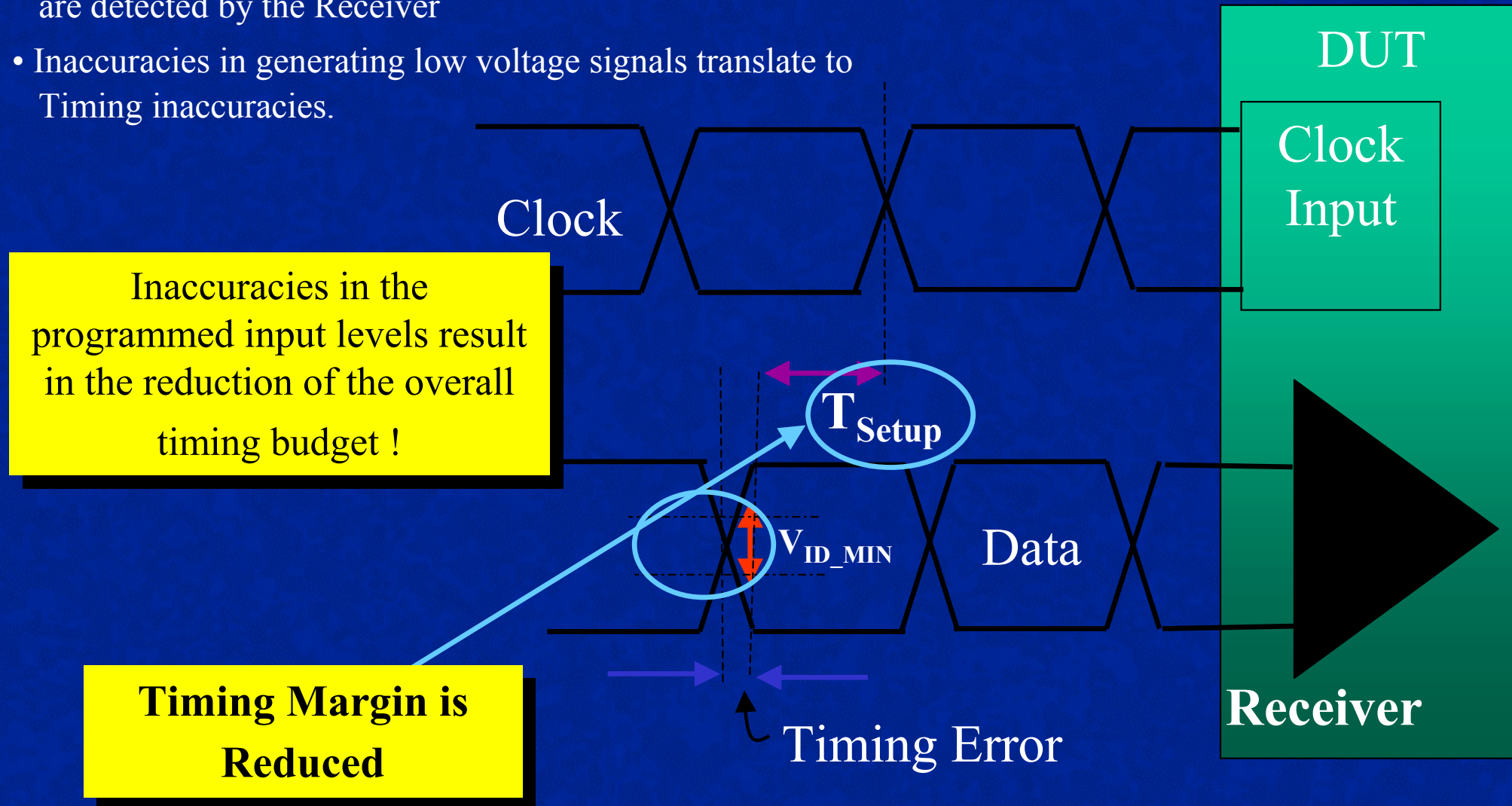


# Testing Output Differential Levels

Voltage Inaccuracies = Timing Inaccuracies

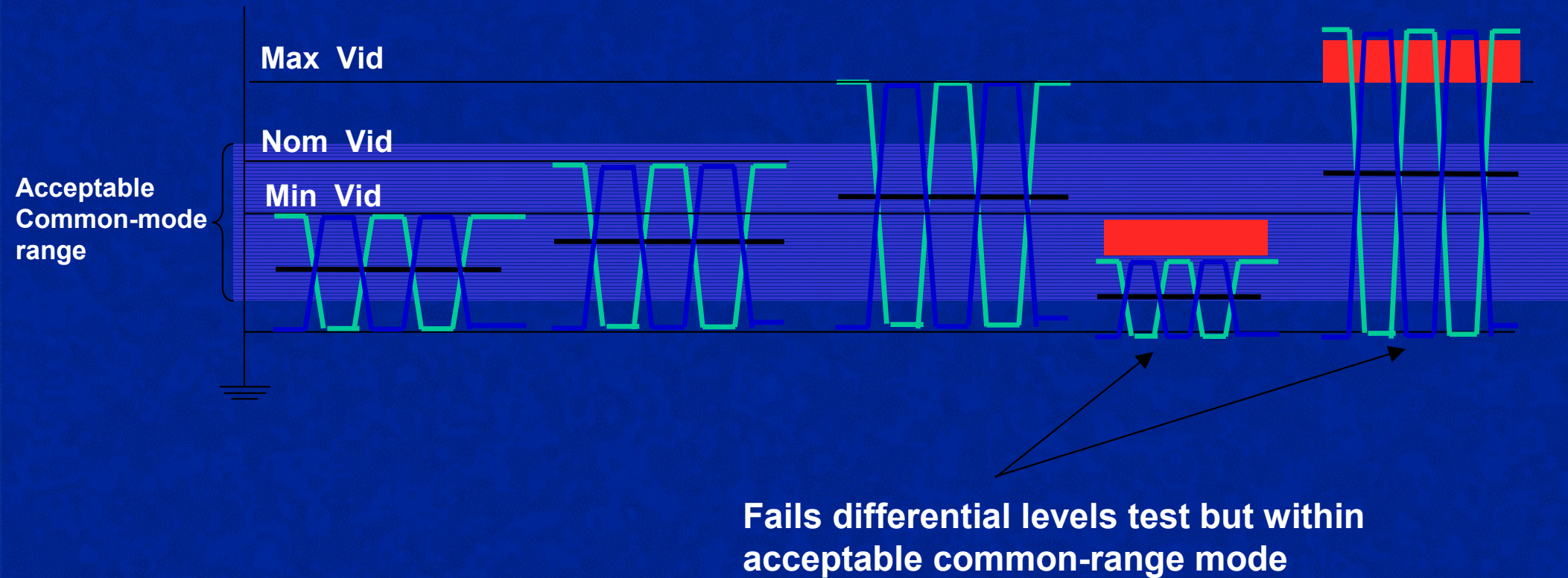
## Differential Receive:

- Only those input signals that are greater than the threshold voltage of the DUT are detected by the Receiver
- Inaccuracies in generating low voltage signals translate to Timing inaccuracies.





# Testing Input Differential Levels



**Test Requirement: Provide a high speed, low voltage, differential signal with a programmable input swing**



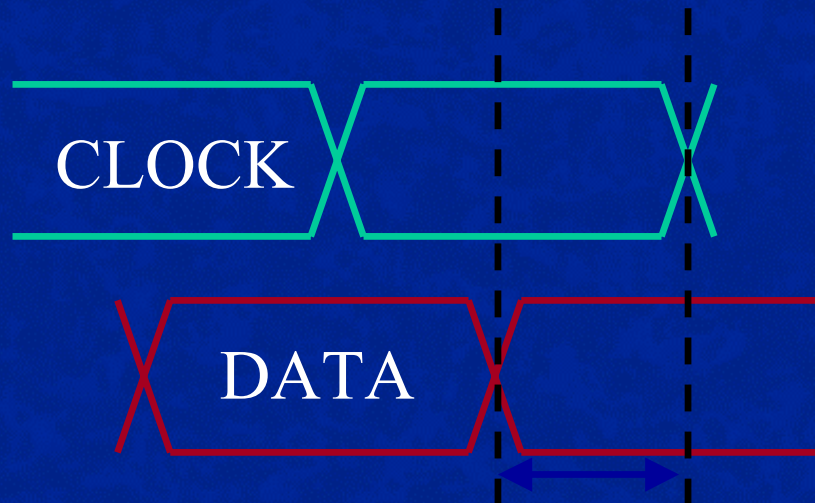
# Timing Tests

	Levels Test				Differential Impedance		Timing Tests
	DC		AC		Tests		Timing Skew
	Common mode Levels	Differential Levels	Common mode Levels	Differential Levels	Impedance Measure	Impedance Verify	
<b>Tx</b>	<b>Vocm</b>	<b>Vod</b>	<b>Vocm</b>	<b>Vod</b>	<b>Ron</b>	<b>Ron</b>	<b>Telk, Tead</b>
<b>Rx</b>	<b>Vicm</b>	<b>Vid</b>	<b>Vicm</b>	<b>Vid</b>	<b>Rt</b>	<b>Rt</b>	<b>Tsetup, Thold</b>



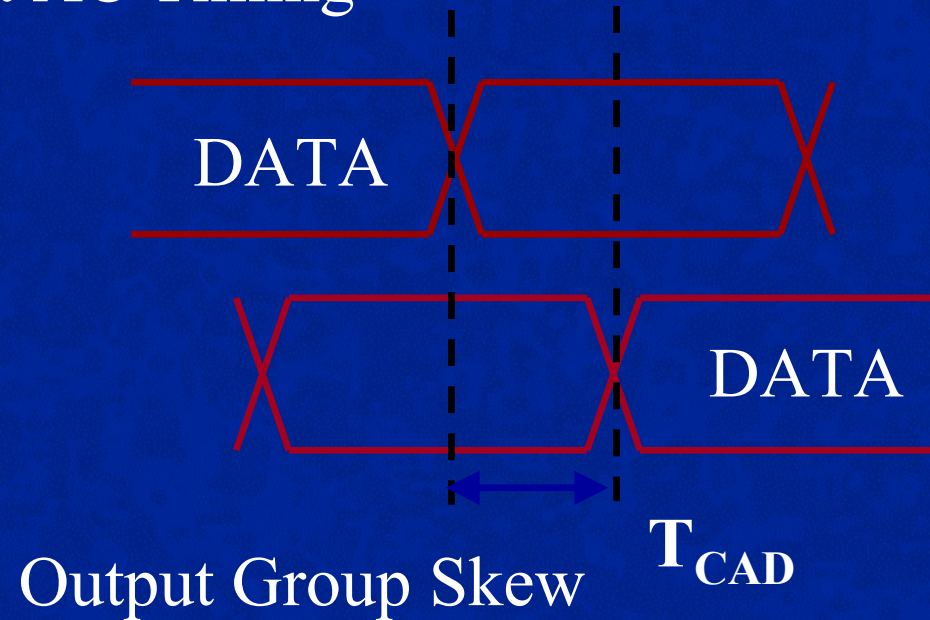
# Timing Tests

## Transmitter Output AC Timing



Clock To Data Skew

$T_{CLK}$



Output Group Skew

$T_{CAD}$

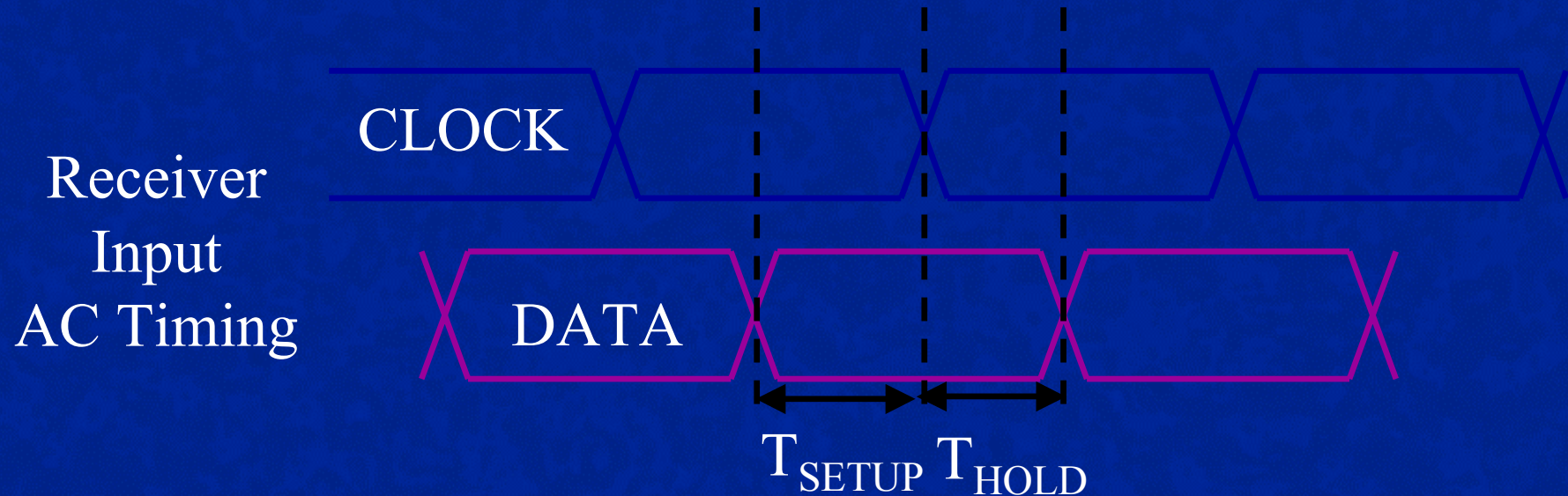
### Test Requirement:

- Device output clock triggers comparators to capture all output data pins
- Provide a variable delay between when the device clock is received and the output data is captured for data eye characterization



# Timing Tests

## Receiver AC Timing



**Test Requirement: Tester transmits input data in sync  
with device input clock**



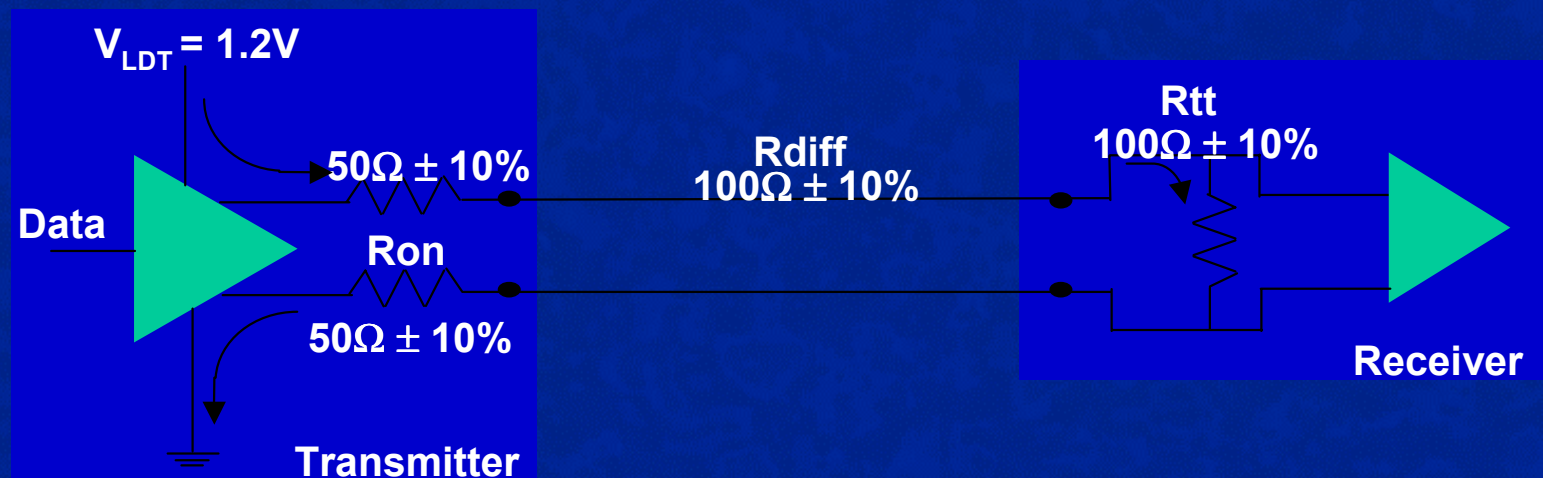
# Differential Impedance Tests

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# Testing Differential Impedance

- Transmitter and receiver impedance's need to be characterized in their operating region
  - Program force voltage
  - Measure current using pin PMU
  - Calculate R for a given process, voltage and temperature using Ohms Law
- Dynamic Impedance Verification
  - HyperTransport uses dynamic impedance control to compensate for variations in Process, Voltage and Temperature



**Test Requirement: Perform single-ended testing with the same channels that perform functional differential tests in a single pass**



# Summary of Key HyperTransport Tests

- Three main test categories

- Levels ✓

- Timing ✓

- Impedance ✓

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<b>Rx</b>	<b>Vicm</b>	<b>Vid</b>	<b>Vicm</b>	<b>Vid</b>	<b>Rt</b>	<b>Rt</b>	<b>Tsetup, Thold</b>

**Teradyne can perform all HyperTransport characterization and production tests**



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